DEFLECTION OR AZIMUTH; WHICH DIRECTION SHOULD THE UNITED STATES FIELD ARTILLERY FOLLOW?

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the forgoing statement.)

ABSTRACT

DEFLECTION OR AZIMUTH; WHICH DIRECTION SHOULD THE UNITED STATES FIELD ARTILLERY FOLLOW? by MAJ James M. McDonald, USA, 85 pages.

This study investigates the use of deflections in the United States field artillery. Deflections are used to align howitzers onto targets during indirect fire. The deflection system is based on azimuths and uses a 6400 mil circle. Howitzers are initially aligned using azimuths and the value of the azimuth is converted to a deflection prior to firing. The point of this study is to determine if there is a need to convert azimuths to deflections.

In order to evaluate the system of deflections this study examines the development and adoption of that system. Research was conducted to determine if another different system was available. A comparison of systems was conducted upon the determination that the only two distinct systems for aligning howitzers are deflections and azimuths. This comparison consisted of gathering information from records and from interviews with senior United States artillerymen.

The comparison of systems indicated that azimuths are the better of the two systems and recommendations are made to adopt the system of azimuths for the United States field artillery.

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CHAPTER I

INTRODUCTION

Field artillery systems throughout the world have a requirement to orient howitzers for direction. The United States field artillery uses a system based on deflections. Other major countries possessing artillery use different methods. Artillerymen have questioned whether the system of deflections is the best for the United States to use. Many think the system of deflections is confusing and contributes to errors that cause accidents. The use of deflections is the basic question of this thesis. Complete research of the subject can reveal if problems exist with deflections. If any problems are evident this same research can be useful in determining solutions. Chapter one introduces the procedures used in orienting howitzers and explains the use of deflections.

Field Artillery weapon systems are used primarily to deliver long range fires through indirect fire. Due to extreme ranges or the weapon being behind a terrain feature, artillerymen often cannot see the target. A hidden gun is an advantage to cannoneers because the location of the weapon is not easily revealed to the enemy. The advantages of long range can certainly be an asset, however, this range and the inability to see the target pose problems. Without the ability to see the target, artillerymen require a method to align howitzers onto the target.

ORIENTING HOWITZERS FOR DIRECTION

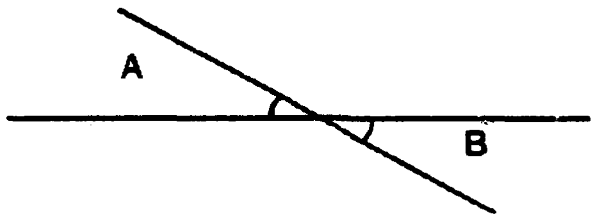
Delivering artillery fires on targets unobservable from the cannon is known as indirect fire.[1] This is the normal method for delivery of artillery fires in the United States Army.[2] Indirect fire relies on the use of an aiming point visible from the howitzer, other than the target since it cannot be aimed on directly. In order to use this aiming point the guns must first be oriented along a known direction. This procedure is known as laying the gun for direction.[3] The use of the four cardinal directions, East, West, North and South, does not provide the accuracy required for the delivery of long range fires. Another system of direction uses degrees of a compass. This system combines the cardinal directions with more definite graduations. The degree system further divides the circle into 360 graduations, each called a degree.

While degrees provide a more precise unit of measure than cardinal directions, they do not meet the needs of long range fire. The unit of measure used in the United

States Field Artillery is the mil, 1/6400 of a circle.[4] These 6400 graduations provide the accuracy required for long range fire. The system of mils is still based on the cardinal directions, it simply allows more precise definition of the desired direction.

The instrument used to align the howitzers along an initial direction of fire is the aiming circle.[5] The aiming circle is an optical instrument that incorporates two scales, both based on the 6400 mil circle. The lower scale is oriented along a given direction of fire, and is known as the non-recording scale. The upper scale, or the recording scale is used to determine the value of angles between the direction of fire and any object. Using these scales the aiming circle can be oriented along a desired direction of fire and then angles measured from that direction. These angles are determined by sighting the telescope of the aiming circle on an object and reading the value of the angle from the upper scale of the instrument. The aiming circle is the primary device used for laying howitzers in the United States Army.[6]

Geometry is used to lay a howitzer for direction. Euclid, a Greek mathematician, developed a theory stating if a line transverses another line the alternate angles formed are equal (Figure 1-1).[7]



ANGLES A AND B ARE EQUAL

Figure 1-1

A derivative of Euclid's theory states, a line that transverses two parallel lines will have equal alternate interior angles (Figure 1-2).[8]

Using the theory depicted in figure 1-2 and superimposing artillery instruments, provides a simple demonstration on laying modern howitzers. Figure 1-3 depicts an aiming circle on one of the parallel lines and a howitzer on the other parallel line. The lower scale on the aiming circle is oriented so that the parallel line that represents the azimuth of fire passes through the scale at the 0 to 3200 position. The azimuth of fire is the

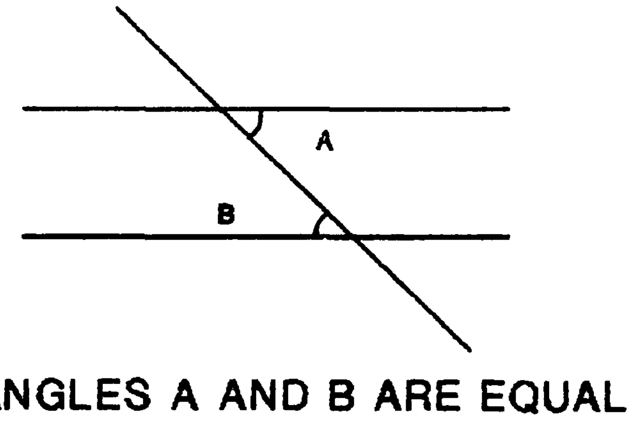


Figure 1-2

direction of initial lay for a howitzer.[9] In figure 1-3 the azimuth of fire is 0800 mils. The barrel of the howitzer will also be aligned with a parallel line. The sights on the weapon are constructed so that the 0 to 3200 line is aligned with the barrel of the howitzer. The breech of the cannon relates to 3200 and the muzzle at 0. Laying the howitzer requires the aiming circle operator and the gunner on the sight of the weapon to aim on each other. Each operator must have the same value on the appropriate scales. Once oriented with the 0 - 3200 line along the azimuth of fire, the aiming circle operator will only measure and announce angles with the upper, non-recording scale. The gunner will set the announced value on the howitzer sight and then move the barrel of the cannon until the line of sight of the howitzer is on the aiming circle. When properly aligned, the 0-3200 lines of both the howitzer and the aiming circle will be parallel, and the instrument readings will be the same. This relates directly to the theory on alternate interior angles being equal. With the aiming circle oriented along azimuth 0800, the barrel of the cannon, now parallel, with the orientation of the aiming

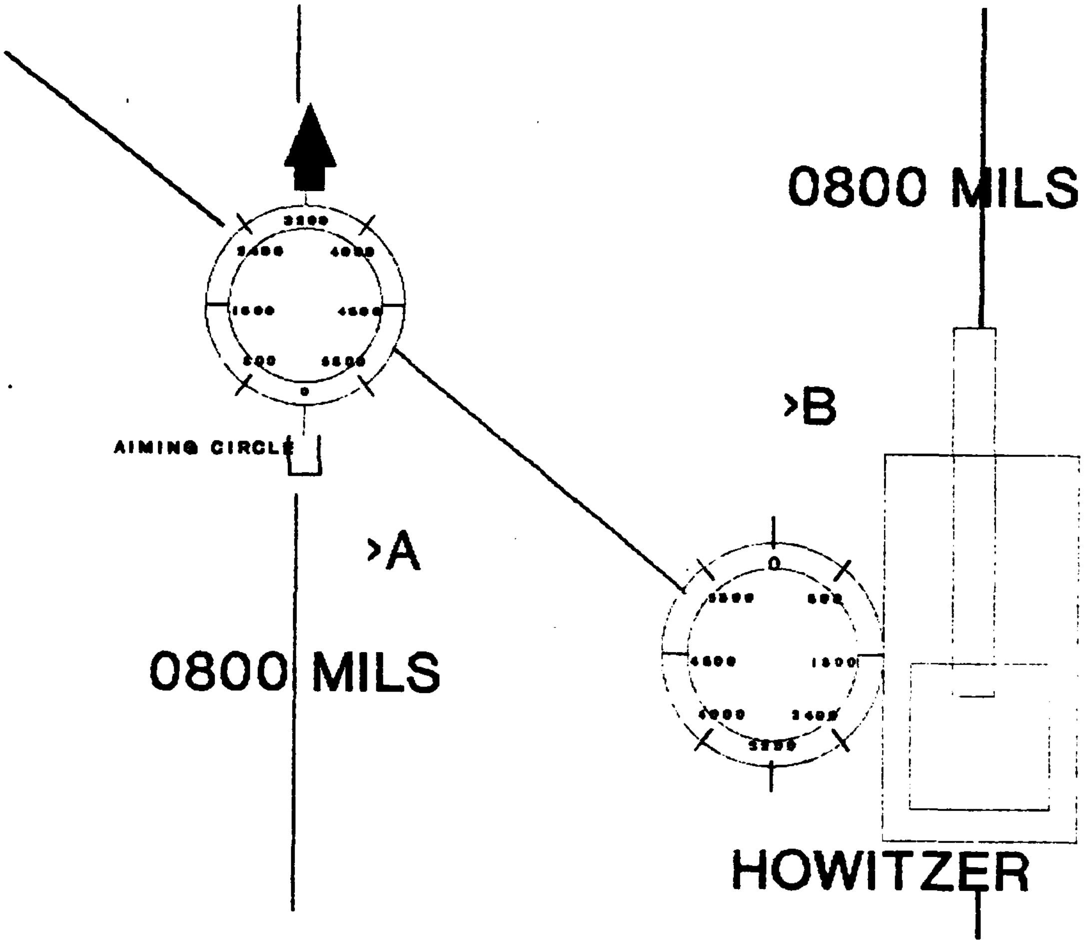


Figure 1-3

circle is aligned on azimuth 0800 mils. The procedure completes the laying of a howitzer for direction.

AZIMUTHS

The howitzer, laid for direction, can now be given fire commands from the battery fire direction center. These commands orient the cannon toward a target. Using the example in figure 1-3, the howitzer is oriented on a direction of 0800 mils, in United States doctrine this is called the azimuth of fire. One approach would be to give the howitzer fire commands based on the azimuth of fire of 0800. Figure 1-4 depicts a target and the relative location between it and the howitzer. The azimuth of fire is also superimposed. The target is located on the right side of the azimuth of fire. An increase in the azimuth will move the direction of the gun closer to the target. For illustrative purposes the direction from the gun to the target is 0850 mils. To reorient the gun onto the target the gun is traversed to the right 50 mils. The gun is now oriented on 0850 mils. This method of orienting howitzers on the target is known as firing using azimuths and is a system used in many countries. The fire command to the howitzer would be "Azimuth 0850."

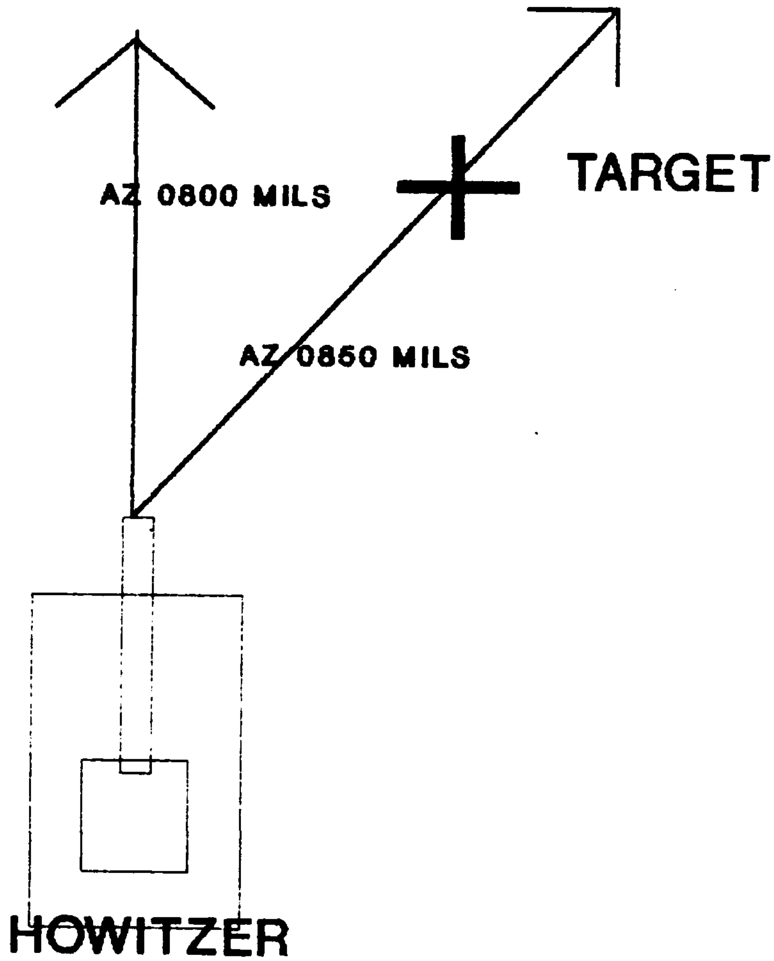


Figure 1-4

DEFLECTIONS

The United States artillery adds an additional step to this process. After the howitzer is oriented on the azimuth of fire, the sights on the weapon are set to read a common deflection. Deflections are the values normally used to orient guns onto a target after the howitzer is laid.[10] Most U.S. systems use 3200 as the common deflection. Another difference associated with deflections is that deflections are numbered in a decreasing value as they are moved to the right or clockwise motion. Figure 1-5 uses the same scenario as figure 1-4. The deflection the howitzer is now laid on is 3200, the common deflection that in this case corresponds to azimuth 0800. The target is on an azimuth from the gun of 0850, however, the fire command must be in terms of deflection. Since the target is to the right of the initial deflection of lay the value of the deflection will have to be decreased by 50 mils to reorient the howitzer to the target. The correct fire command for the howitzer is now "Deflection 3150".

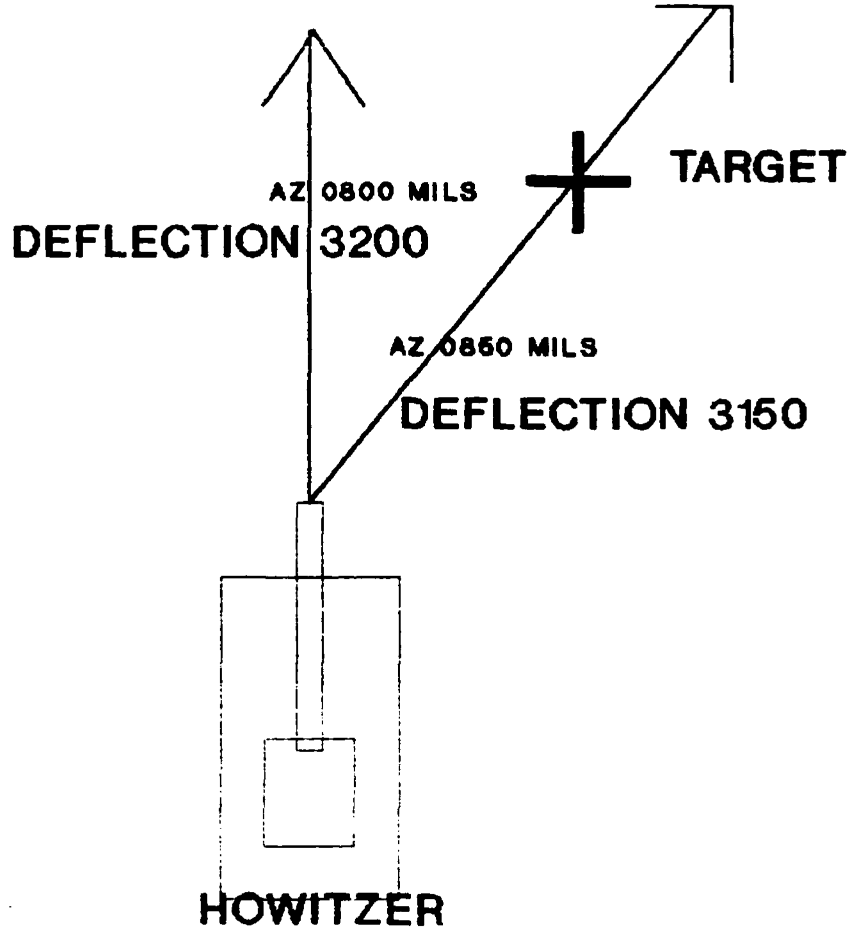


Figure 1-5

RESEARCH QUESTION

The preceding text describes the requirement and reasons for orienting field artillery howitzers, as well as describing the use of deflections in the United States field artillery. The issue of the use of deflection poses the research question of this study. Are deflections the best method for orienting howitzers for direction? In an attempt to answer this other questions surface. These subordinate questions include: Why does the United States field artillery use this system? Is there some technical or tactical reason for using deflections? What caused the United States to adopt a system of deflections? The advantage of adding the extra step in converting azimuths to deflections appears to have no value. An historical study will reveal any advantage or disadvantage to this system. What are the other options available? This question will be answered by reviewing artillery procedures from other nations. Are artillery systems under development using the deflection system? There are presently two howitzer systems under design for the United States artillery, the Paladin and the Advance Field Artillery System. Each of these weapons use a more automated system of fire control and may not be tied to the system of deflections as we know it. Each subordinate issue when fully addressed will contribute to the answer of the primary question.

LIMITATIONS

The topic of this thesis was subjected to only one actual limitation. This limiting factor is the inability to use the azimuth procedure, described earlier in this chapter, on present United States weapon systems. Using the azimuth system would require a modification to the sights of the howitzer and to the software of the fire direction computer used in the fire direction center. While this equipment is available in a country as close as Canada, funds are not available for obtaining and testing this equipment as a portion of this research.

DELIMITATIONS

Constraints imposed on this study are done in the interest of limiting the scope of the thesis to the determination of which is the best system of orienting howitzers for direction. While costs of each system will be used as a criteria in the comparison of systems in chapter IV, the actual determination of those costs will not be calculated. Determining actual costs is a project worthy of a separate thesis and an attempt to do so in this research would change this paper from a feasibility study to a fact sheet on the cost of conversion. The other major limiting factor imposed on this research is the study of firing incidents, which will include only a representative sample of incidents. An attempt will not be made to cover all firing incidents in this country or any other nation.

SIGNIFICANCE OF THE STUDY

Numerous firing errors have possibly been caused by confusion associated with the deflection system. Examples of this are casualties from Vietnam that include 2 dead and 14 wounded in a one month period.[11] The value of this study is that it provides the United States field artillery the facts on the use of deflections. Studies have not been published on the subject and the information from this research will be useful in determining if deflections should be included in future systems. If the study proves that deflections are a superior system then the decision to incorporate them in future systems will have some basis. If another system proves to be superior, future systems should be designed to exclude deflections and use the most efficient and effective means. In either case the determination of which system to use will be assisted by this study. The long range impacts of these decisions are potentially significant. The system used for the United States field artillery will be used in all future artillery training events as well as in any armed conflicts. The selection of the best system will have impact on training costs, effectiveness and will potentially impact on the performance of the United States field artillery in future conflicts.

CHAPTER ONE ENDNOTES

[1]U.S. Army, TC 6-40, Manual Cannon Gunnery (Washington: Department of the Army, 1988), Glossary-10.

[2]Ibid., 2-1.

[3]U.S. Army, TC 6-50, The Field Artillery Cannon Battery (Washington: Department of the Army, 1988), Glossary-10.

[4]TC 6-40 (1988), Glossary-10.

[5]TC 6-50 (1988), Glossary-6.

[6]Ibid., 4-8.

[7]Miller, Leslie H., College Geometry (New York: Appleton-Century-Crofts, Inc., 1957), 7.

[8]Thompson, J.E., Geometry for the Practical Man (Princton: D. Van Nostrand Co. Inc., 1962), 48.

[9]TC 6-50 (1988), Glossary-6.

[10]TC 6-40 (1988), 9-14.

[11]Colonel Tony F. Perpich, "Report of Staff Visit -RVN 8-21 June 1967", (Ft. Sill: United States Artillery and Missile School, 26 June 1967.

CHAPTER 2

DEVELOPMENT AND USE OF DEFLECTIONS

To better understand the use of deflections a study of the origin of the term is necessary. Because deflections are used primarily in the United States field artillery, the majority of the history will be from the United States perspective. Deflection was initially a term describing a change in direction of fire. This term evolved, through different applications involving weapons in service, into what we now know as deflections. Future systems for the United States field artillery are being designed to use azimuths, however the same evolutionary process that has required the use of deflections is introducing deflections into the new systems.

EARLY SYSTEMS

Artillery began as a direct fire system that hurled large stone balls at the walls of ancient fortifications.[1] Early cannons were extremely heavy and almost immobile, making them an asset only in static warfare. Innovations in artillery were primarily directed toward improving mobility. Reductions in size and weight of the cannons provided field armies with guns that could accompany them on campaigns. Field artillery, regardless of the size, remained largely a direct fire weapon and continued to be so until well after the American Civil War.[2]

INDIRECT FIRE

Experiences from the American Civil War demonstrated that artillery needed to be located out of sight and range of the infantry's rifles. European nations took the developmental lead in the factories of Krupp in Germany and Schneider in France. Both nations designed and constructed cannons that were breech loading and capable of indirect fire.[3] The Schneider 75mm howitzer of 1897 was the first to have an efficient recoil system and became the gun that all nations attempted to duplicate.[4] Indirect fire had not been practical before this time because the recoil of firing moved the weapon and it had to be returned to its exact location after each round was fired. If the weapon location changed even a small amount between rounds sighting on an object other than the target was inaccurate and made indirect fire impractical. An effective recoil system prevented the gun from moving off its original location after each round was fired. Artillery pieces with recoil systems could now be used in indirect fire because the weapon could be sighted on an object other than the target. The development of recoil systems provided gunners the capability to engage the enemy from protected positions.

The French 75mm Model 1897 provided artillerymen the opportunity to practice indirect fire. The armies of World War I adopted this technique quickly.[5] The United States artillery followed the same path as the European nations and even used the French 75mm as their standard field piece. Like the other nations, the United States delivered most of its fire using the indirect method.

The practicality of indirect fire was known and used by the United States artillery but the transition of the field manuals was slower than the acceptance of its use. After the war, artillery field manuals included the procedures for indirect fire but the emphasis remained on direct fire. The common way to lay a howitzer was to direct the section chief to sight on the primary target in the engagement area. Deflection was a term used only to designate shifts of the line of fire from this target, such as "Deflection left 120 mils."[6] Direct fire continued to be taught in the United States Artillery throughout the 1920s.

In the early 1930s indirect fire took precedence over direct fire in the manuals. In 1932 the primary gunnery manual, Field Artillery Gunnery, Book 160, stated "indirect laying is the usual type of laying."[7] Indirect laying was the process used to orient the barrels of the howitzers for indirect fire. The guns were laid on a base deflection, or direction of fire, and given corrections in relation to that base. For example, a correction to move the tube of the howitzer to the right would be given as "Right 690 mils." This command would cause the howitzer to be aligned 690 mils to the right of the initial base deflection.[8]

Other nations oriented artillery in much the same manner in the early 1940s. The Royal Artillery of Great Britain oriented the guns of a battery on a line produced by the Gun Position Officer. This line was given a value of 0.[9] Changes to the line of fire were then ordered as a left or right shift from the line of orientation.[10] The German Artillery also reoriented artillery by giving right and left shifts from the base deflection.[11] In each country deflection was a term that was associated with the direction of fire of artillery pieces.

ADVANCES IN FIRE DIRECTION TECHNIQUES

In early 1941 the United States Artillery revised the primary gunnery manual and designated that the Executive Officer of the battery would orient the unit to the nearest

100 mils based on the rough direction of fire announced by the Battery Commander.[12] The battery would then register its fire on a target. This registration consisted of the battery firing at a target and adjusting its fire until the impact of the rounds were on the target. When the battery had successfully registered the target, the base deflection for the battery was recorded as the final direction used to engage the registration point.[13] This system provided the firing unit with accurate data for the registration point. Fires in the vicinity of the registration point could also be delivered with excellent confidence that they would be accurate.

The United States artillery community became interested in techniques that massed the fires of several batteries onto a target. Massed fires is a term that describes the gathering of the fires of several units onto a target, not massing the guns of units at the same location. Massing fires of artillery produces more devastating effects in the target area. The method of registering batteries was excellent for battery fire but did not aid in massing fires from several units. Fire direction techniques up to 1940 had addressed only battery level fires. The United States Field Artillery School in 1941 made sweeping changes in the procedures of fire direction. In order to mass fires at the battalion level the fire direction centers for each battery were located at the battalion headquarters. This enabled the battalion to exercise more control over the fire of each unit. Batteries were then laid on a common base deflection and changes to the direction of fire were ordered as corrections to that base deflection, such as "left 151 or right 168."[14] The method of registering each battery became obsolete leaving only one battery to register. The correction obtained from this registration would then be transferred to the other batteries in the battalion.[15] This procedure led to the use of a common deflection. A common deflection was nothing more than each battery being laid on the same azimuth of fire. Corrections computed as a result of registrations were easily applied to the other units since the value of the initial or common deflection was the same.

POST WORLD WAR II

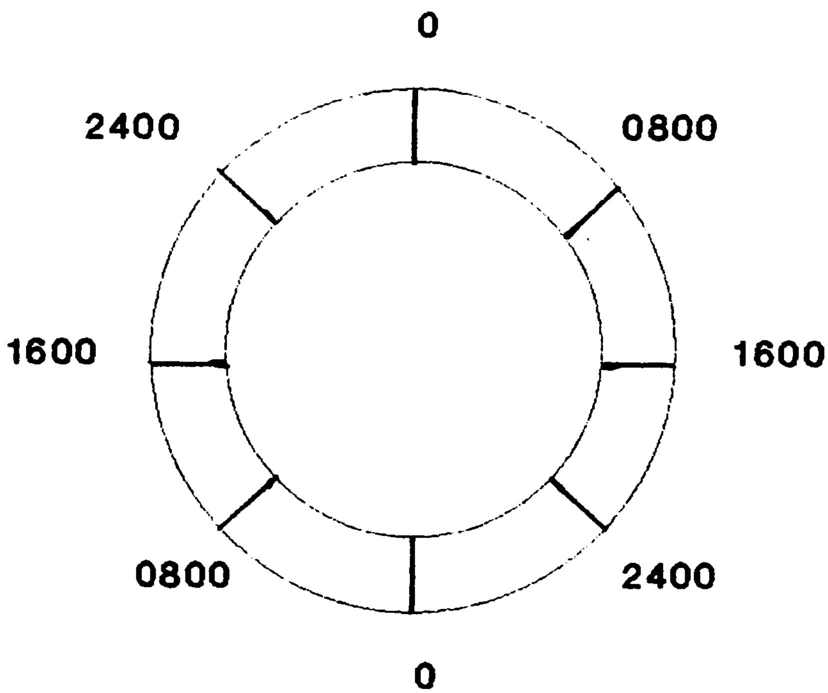
The use of common deflections remained unchanged throughout World War II.[16] After the war, the artillery community held conferences to assess and improve the procedures used. In a major conference held at Fort Sill in 1946 a topic of great discussion was whether the United States artillery should produce a mechanical device for fire direction similar to the one the Germans used. The decision from the conference was that our procedures were sound and a new device was not required. It was recommended, however, that our procedures be refined and updated.[17]

Field Manual 6-40, Field Artillery Gunnery, 1950, contained major changes from the previous edition. Five years had elapsed since the last revision and many changes had occurred as a result of the post war conference of 1946. One change was in the use of the term deflection. Orders to the guns to move the barrel of the howitzer had previously been sent in the form of shifts to the base deflection. A routine order had been "Right 136", or "Left 240." The change dictated that fire commands would be sent to the guns as deflections, for example "Deflection 2750", or "Deflection 2975."[18] Since the commands were not sent as shifts the common or base deflection had to be given a value. No standard was designated as the value for the base deflection, however, the most commonly used values were between 2400 and 2800 mils. Most weapons in use were only capable of moving or traversing the barrel of the weapon 400 mils to the left or right. Since the sights on the weapons were numbered from 0 to 3200 mils the use of a deflection of lay of 2800 mils or less would ensure that a maximum shift of 400 mils could still be applied to the sight. For example 2800 mils plus 400 mils, the maximum shift for a weapon, would be 3200 mils, the greatest value that could be set on a sight numbered 0-3200 mils. The other major change in this edition of the gunnery manual was that deflections would increase as the cannon was moved to the left and decrease as it moved to the right.[19]

Since deflections were used in fire commands, the value of these commands had to be placed on the sight of the weapon. As previously stated the sights of the howitzers were numbered from 0 to 3200 mils. The actual sights were based on a 6400 mil circle; this circle was numbered using two semicircles, both reading 0-3200 mils. The sight values increased in a clockwise direction. (Figure 2-1) Each sight had two scales, both numbered in the same manner. The upper scale was the scale that the weapon was laid with. This was a fixed scale with the 0-3200 line oriented along the barrel of the howitzer. This scale, or main scale, when properly aligned, allowed the alternate interior angles between the weapon and the aiming circle to be equal. This procedure permitted the howitzer to be laid for direction as discussed in chapter I.

Since the sights on the weapon were numbered clockwise, the mechanics involved with using these sights caused the barrel of the howitzer to move to the left when the deflection was increased. This is the reason deflections increase to the left and decrease to the right. This scale on the sight was not fixed and was known as the slipping scale. The value on the slipping scale could be changed, without moving the barrel or the sight, and allowed the azimuth of lay to be displayed as the common deflection. An example of this is, the azimuth of lay was 4900 mils and once laid the slipping scale was reoriented to make that value 2800 mils. This scale was now used for firing and is known as the shooting scale. If the shooting scale had been numbered counterclockwise then there would have been no need to use deflections in a counterclockwise manner. Likewise, if the shooting scale was numbered 0-6400 in a counterclockwise orientation, then azimuths could have been used rather than deflections.

Since the early 1950s the only significant changes in the use of deflections were in the designation of values for the common deflections and the introduction of the M100 series sight. The use of common deflections came into practice in World War II so that all fire units were oriented along a common direction. The designation of a standard value for these deflections did not appear until the late 1950s. The 1957 edition of FM 6-40 included common deflections for the weapon systems in use. (Table 2-1)[20]



OLD STYLE SIGHT

Figure 2-1

WEAPON	DEFLECTION
75 mm howitzer	2200
105 mm howitzer	2600 or 2800
4.2 inch mortar	2800
155 mm howitzer	2400
155 mm gun	2600
8 inch howitzer	2600
8 inch gun	2200
240 mm howitzer	2200
280 mm gun	2200

COMMON DEFLECTIONS

TABLE 2-1

The introduction of the M-100 series sight in the mid 1960s was the last major change in the use of deflections and produced the system still in use today. This new sight was numbered 0-6400 mils as opposed to the older sights numbered 0-3200 mils. The shooting scale no longer incorporated a slipping scale. The slipping scale was replaced by a scale with a reset plunger. When this plunger was depressed the shooting scale reset to 3200.[21] The shooting scale was numbered clockwise and did not affect the system causing deflections to decrease to the right. The only value a M-100 series sight could be reset to was 3200 mils. In the active army today the primary sight in service is the M-100 series, explaining why the common deflection for United States field artillery is considered to be 3200 mils.

NEW WEAPON SYSTEMS

Weapon systems under near term development and newly acquired weapons have also been required to maintain a system of deflections. The M119 105mm Howitzer is the newest addition of cannon artillery to the arsenal of the United States Army. It is replacing the M102 105mm Howitzer in use in the light divisions of the army. The M119 is a variant of the British Light Gun. The British Light Gun is fitted with a dial sight that has two scales, not unlike our sights. The lower scale is the shooting scale and is numbered in a counterclockwise manner. This configuration allows the howitzer to shoot using azimuths rather than deflections. One of the American modifications made to the British Light Gun was to include the M100 series sight to permit the use of deflections.[22]

The M109 series 155mm howitzer is the primary weapon in use in the United States Field Artillery today. The replacement for this howitzer, the Paladin, is a modification of the existing weapon system. The Paladin is much more than an upgrade of the M109. It incorporates state of the art technology which make the Paladin revolutionary in howitzer design. The Paladin has on board position navigation equipment and is capable of computing its own fire commands. This equipment allows Paladin to act as an autonomous howitzer. Paladin does not need to be externally laid or provided fire commands. The data the howitzer uses for direction is based on azimuths, not deflections. The fire direction computations are, however, converted into deflections and displayed to the gunner. This is provided so that in the event the gunner is required to operate the sight in a conventional manner, he is able to apply deflections provided to him from a battery computer system.[23] Paladin is scheduled to be employed in the mid 1990s.

Another weapon system under design is the Advanced Field Artillery System (AFAS). This weapon system will also be capable of autonomous operations and the fire control solution will also be based on azimuths, not deflections. The current plan does not include converting azimuths to deflections. The reasoning behind this decision is the howitzer will not have conventional sights so there would be no use in providing the gunner fire commands. AFAS will have sights that use laser technology for alignment. This weapon system is projected to be in use in approximately 2005.[24]

USE OF THE TERM DEFLECTION

As indicated in the preceding text, the term deflection has had several different meanings since the turn of the century. A definition from a modern dictionary reads, "The deviation from zero shown by the indicator of a measuring instrument."[25] This definition applied to the artillery use until the early 1950s. With the advent of transferring registration corrections the artillery began to use the term common deflection. This use of deflection referred to the deflection as the direction of fire, and in

1950 was actually given a value. In 1953 there was apparent confusion over the term deflection and Ft. Sill published the following definition.

> Deflection, 1. setting on the scale of the sight of the gun to place the line of fire in the desired direction. 2. horizontal clockwise angle between the axis of the bore and the line of sighting.[26]

The 1953 definition accurately described the practical term for deflection as well as the technical term. This is also the definition that the current gunnery manual uses. The procedural manual used in the firing battery, Training Circular 6-50, lists the definition as followings.

> Deflection- The horizontal clockwise angle from the line of fire, or the rearward extension of the line of fire, to the line of sight of a designated aiming point with the vertex of the angle at the sight. In addition to deflection as a fire command, the firing battery is concerned with both common deflection and referred deflection.[27]

The use of the term deflection has been confusing over the years. The current definitions still leave some room for possible confusion. With this confusion the possibility for continued changes in the use of the term does exist. In 1963 the United Kingdom Royal Artillery School published a study comparing the use of deflections and azimuths. This study concluded that deflections had no advantages over azimuths. The major shortcoming in deflections was identified as the possibility for confusion over needlessly converting azimuths to deflections.[28]

The preceding brief history explains how the United States Field Artillery adopted the use of deflections. The decision to use deflections as we do today was not one made at a conference or through a major study, it was a gradual evolution based on requirements of the day and equipment that was on hand. The trend in the United States is to keep deflections in future systems. Possible reasons for keeping this system are the amount of equipment on hand that uses deflections and that gunners are familiar with the use of deflections and to change would require a complete retraining process. The purpose of this thesis is to determine if there is a better system for the United States field artillery.

CHAPTER TWO ENDNOTES

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[14]Field Artillery School, "Fire Direction," Field Artillery Journal 31 (May 1941): 287.

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[18]U.S. Army, FM 6-40, Field Artillery Gunnery (Washington D.C.: Department of the Army, 1950), 118.

[19]Ibid., 118.

[20]U.S. Army, FM 6-40, Field Artillery Gunnery (Washington D.C.: Department of the Army, 1957), 43.

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[24]Captain Peter R. Ostrom, Assistant Project Manager, Advanced Field Artillery System, Interview by author, 4 October 1991, Ft. Sill, Oklahoma, Author's notes.

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CHAPTER III

METHODOLOGY

This chapter describes the methodology and research techniques used in this thesis. The overall strategy in chapter I was a review of the current use of deflections, and an introduction to the research question. Chapter II focused primarily on the historical aspects of deflections and included the direction the United States field artillery is headed in the future with respect to deflections. The remainder of the research was devoted to gathering information concerning deflections and systems used in other countries. Once the information was gathered, analysis and recommendations for use and further study complete this thesis.

CHAPTER I

Chapter I was a review of current procedures. Included in that chapter was a litany of technical terms. When required, these terms are defined as introduced. Other terms not defined are included, along with the previously defined ones, in a glossary after chapter five. This glossary can be used as a quick reference on the artillery specific technical terms used throughout the paper. The bulk of the information in chapter I was compilation of the techniques currently used in the United States field artillery. Information was obtained through a review of current doctrinal literature and through the experience of the author. The qualifications of the author include over eleven years as a practicing artilleryman, experience as a gunnery instructor in the United States Field Artillery School and experience as an Instructor in Gunnery at the Royal Canadian Field Artillery School. Also included in chapter I were limitations, delimitations and the significance of the study. The first chapter was designed to give the reader a base of knowledge on the use of deflections.

CHAPTER II

Chapter II provided information on how the United States adopted the system of deflections and aspects concerning the future use of deflections in new weapon systems. Initially a search was conducted using the Defense Technical Information Center available in the Combined Arms Research Library, Ft. Leavenworth, Kansas. This search produced a listing of many volumes covering the tactical use of artillery throughout the history of the United States

Field Artillery. The search provided scarce information on the technical aspects of fire direction. A review of the technical listings available in the Combined Arms Research Library did shed some light on the use of deflections and provided the first breakthrough toward the origin of deflections.

While the information available in the Combined Arms Research Library was helpful, it was incomplete in providing the source of deflections. A listing of publications available in the Morris Swett Technical Library, Fort Sill, Oklahoma appeared to be more complete and a trip was made to use that facility. The Fort Sill visit proved to be invaluable. The primary sources available at the Field Artillery School in the Morris Swett Technical Library led to the answers on the origin and adoption of deflections. These findings were the focus in chapter II. While at Ft. Sill interviews were arranged with assistant project managers in the Department of Combat Developments to ascertain the use of deflections in future systems. The results of these interviews were also included in Chapter II. An interview with GEN (Ret) Charles P. Brown conducted 21 December 1991, validated the history and use of deflections. GEN Brown, a former post commander of the Artillery Center at Fort Sill, was the Chief of Resident

Instruction at Fort Sill in the early 1950s. GEN Brown agreed with and confirmed that the information described in chapter II is the correct description on the evolution of deflections.[1]

NEW RESEARCH

The gathering of new research dealt primarily with obtaining information concerning the advantages and disadvantages of the use of deflections. Interviews were extremely valuable in gathering this data. Among those interviewed were the Assistant Commandant of the Field Artillery School, and the Directors of Fire Support and Combined Arms Operations, Training and Doctrine, and Target Acquisition Departments. The Chief of Cannon Division, Gunnery Department was also interviewed as well as the Liaison Officers of The United Kingdom, France, Germany and Canada. These interviews provided invaluable information in supporting arguments for established questions and the formation of other areas to explore.

The primary tool used in the interviews was a questionnaire developed originally as a survey. (Figure 3-1) The point of departure in forming the questionnaire was the criteria used in the comparison of systems that is described in chapter IV. These criteria include safety, efficiency of the system, integration of deflections into new systems, training issues, interoperability, and costs associated with converting systems. These criteria were converted into questions forming a document that was cumbersome and too broad in scope. The original questionnaire was only useful if given to an individual who had completed considerable research in the subject. In order to overcome these problems the questionnaire was reduced to questions dealing with the use of deflections and the use of azimuths as opposed to deflections. The chosen audience was senior field artillerymen in order to gain from their collective experience. The Directorate of Academic Operations in the Command and General Staff College has compiled a handout that addresses the design and construction of surveys. This document was instrumental in refining and polishing the draft questionnaire. After an initial review with the thesis committee chairman, LTC Raletz, the questionnaire was once more revised and distributed to three Artillerymen for final comments. Minor adjustments were then made and the questionnaire was used for a trial interview on six individuals. The questionnaire proved to be a great aid in the interviews and few changes were needed as a result of these initial interviews.

DO YOU HAVE EXPERIENCE AS?

____DIVARTY/BDE CDR ____DIVARTY XO ____DIVARTY S-3 ____BN CDR

____BN XO ____BN S-3 ____BN FDO ____BTRY CDR ___OTHER____

DO YOU FEEL THAT THE POSSIBILITY FOR CONFUSION EXISTS OVER THE CONVERSION OF AZIMUTHS TO DEFLECTIONS? YES NO
COMMENTS:

OTHER THAN COMPATIBILITY WITH U.S. EQUIPMENT, DO YOU KNOW OF A NEED TO CONVERT AZIMUTHS TO DEFLECTIONS? YES NO
COMMENTS:

IF U.S. ARTILLERY EQUIPMENT WAS MODIFIED, DO YOU FEEL IT WOULD BE AN IMPROVEMENT TO USE AZIMUTHS AS OPPOSED TO DEFLECTIONS? YES NO
COMMENTS:

DO YOU KNOW OF ANY FIRING ERRORS THAT WERE CAUSED BY CONFUSION ABOUT DEFLECTIONS? YES NO
COMMENTS:

DO YOU FEEL THAT GUNNERS AND SECTION CHIEFS WOULD HAVE SIGNIFICANT PROBLEMS CONVERTING TO A SYSTEM OF AZIMUTHS IF GIVEN TRANSITION TRAINING? YES NO
COMMENTS:

DO YOU KNOW OF WAY TO ALIGN GUNS OTHER THAN AZIMUTHS OR DEFLECTIONS? IF SO PLEASE DESCRIBE IT. YES NO

WILL OFFICER ALLOW THIS INFORMATION TO BE ATTRIBUTED TO HIM? YES NO

QUESTIONNAIRE

Figure 3-1

Other interviews included personnel from the United States Navy, primarily to determine what system this branch of service uses in orienting the guns on board ships. Several foreign officers were interviewed to determine what system is used in their countries. This area was explored to determine if any system other than the deflection or azimuth system existed. The Safety Center at Fort Rucker, Alabama was contacted to obtain information on firing accidents that were directly attributable to the use of deflections. Range Control at Fort Sill was also queried on firing incidents statistics involving deflections. Finally, the Center for Army Lessons Learned, Fort Leavenworth, Kansas was searched for records pertaining to firing incidents at the National Training Center, Joint Readiness Training Center and The Combat Maneuver Training Center. All searches and interviews were conducted to answer the research questions as well as to gather information for the comparison of systems to be used in chapter IV.

CHAPTER IV

Once the information was gathered the task of analyzing the information began. Chapter IV is dedicated to this analysis. The tool used in this analysis as previously mentioned is comparing the systems. This comparison addressed the areas of safety, efficiency of the system, integration of deflections into new systems, training issues, interoperability issues and costs associated with converting. Each of these areas was weighed against the two emerging systems, deflection and azimuth. These two systems were determined, through interviews and research, to be the basic systems used to align the howitzers in the United States and other countries. This research found no other distinctly separate form of orienting howitzers.

The subordinate questions posed in chapter I were oriented primarily toward why and how the United States field artillery adopted and continues to use deflections. These questions were addressed in chapter II. The analysis of chapter II indicates that there was no significant issue that caused the use of deflections. It was simply an evolution of a term and the adaptation of the term to the equipment on hand. With these questions answered only the primary question remained, "Are deflections the best method for orienting howitzers for direction?" The criteria used in the comparison are designed to evaluate the two known systems against each other to determine which system is better. Each criteria was researched through literature and interviews to determine the relative importance to both systems. The results of the comparison of systems reveals the best system available.

Chapter V is a report on the analysis of the two systems and the recommendation on the use of the best system. Recommendations for the integration or continued use of that system are presented, as well as suggestions on areas needing further research. The results of chapter V are designed for use in the consideration of which system the United States field artillery should use to align howitzers.

CHAPTER THREE ENDNOTES

[1]Brown, Charles P., General (retired), United States Army, Former Commandant, United States Field Artillery School, Interview by author, 21 December 1991, Lawton, Oklahoma, Author's notes.

CHAPTER IV

DISCUSSION

To evaluate the system of deflections many areas were researched. Inquires were made into current systems in other countries and other similar systems, such as naval guns. Through the research of the methods used in other countries it was determined that only two viable systems are available for comparison, azimuths and deflections. These two systems were then compared using the criteria of safety, efficiency, integration into new systems, training impacts, interoperability and costs. The findings of the research and the analysis of that information should reveal which system is best for the United States field artillery.

OTHER SYSTEMS

One avenue to explore was to study the systems of alignment other nations used. Because technical manuals of other countries were not readily available, interviews with foreign artillery officers became the source of the necessary data. The countries examined were Australia, Canada, France, Germany, Italy, United Kingdom and Venezuela. Of the seven countries listed, five use azimuths exclusively. These are Australia[1] Canada[2], France[3], Germany[4] and United Kingdom[5]. Venezuela has weapon systems that use both deflections and azimuths. Venezuelan weapons are grouped in different battalion sized units so that the two systems are not intermingled.[6] Italy was the only country that had a system that differed from deflections or azimuths. Italian howitzers are laid for direction and that initial direction is then given a value of zero. Shifts of the line of fire are then ordered from zero. A shift to the right increases the value, such as 125 mils and to the left decreases, such as 6350 mils. This system uses mils in laying and announcing shifts.[7]

The U.S. Navy's system of gun alignment was also investigated. In this process the guns are directed on to the targets using a system of azimuths not based on an initial azimuth of lay but on actual azimuths from the ship's gun to the target. Since a ship is constantly moving the fire control equipment must calculate a new azimuth to the target for each round.[8] The majority of the systems examined use azimuths. The one system that uses something different, the Italian system, is more closely related to azimuths than deflections. This system presents no new way to align the howitzers, it is merely a technique of the azimuth system and a separate evaluation of the merits of this system is not required. The remainder of the research will be focused on the two predominate systems, azimuths and deflections.

COMPARISON OF SYSTEMS

With the focus of the study narrowed to azimuths and deflections, specific criteria was required for a more thorough evaluation. The basis of this comparison was to determine which system is the better of the two. Specific criteria address issues that evaluate several key aspects of artillery equipment. These criteria are safety, efficiency, integration into new systems, training impacts, interoperability and costs associated with each system. Safety is an extremely important issue in any discussion of artillery. Given that the purpose of artillery projectiles is generally to cause some type of damage it becomes very clear why safety is a key consideration. Any system that displays distinct advantages in the safety arena is certainly worthy of evaluation and consideration as a possible system to use. Efficiency refers to the ability to quickly and accurately bring fires onto a target; a system must be efficient and easy for artillerymen to use and understand. The two systems will be evaluated on the ease and speed of use and the ability of the users to understand the system, or the efficiency of the system. Artillery systems are constantly being designed and improved, an evaluation of any system should be viewed with the possibility of its integration into these new systems. Training is also very important to any artillery system. Good systems are ones that soldiers and their leaders can use through a minimum of training and any system that eases that load is an asset. It is likely that future wars will be fought in some type of coalition warfare. If this is true then the system used should be one that can interface with other countries likely to be our allies. Of course no evaluation would be complete without at least addressing costs. As stated in the beginning of this paper a specific breakdown of costs will not be made. However, costs will be examined in a macro sense to present which system is likely to be the most cost effective. The remainder of this chapter will deal with the evaluation and analysis of these criteria.

One tool that will be used throughout the comparison of systems is the survey that was used as a basis for the interviews with United States artillerymen. A copy of the completed survey is summarized in figure 4-1.[9] The results

DO YOU HAVE EXPERIENCE AS?

_4_DIVARTY/BDE CDR _1_DIVARTY XO _3_DIVARTY S-3 _7_BN CDR

_7_BN XO _8_BN S-3 _2_BN FDO _10_BTRY CDR _8*_OTHER

*SEE LIST OF OTHER POSITIONS BELOW

	YES	NO	*NR
DO YOU FEEL THAT THE POSSIBILITY FOR CONFUSION EXISTS OVER THE CONVERSION OF AZIMUTHS TO DEFLECTIONS? COMMENTS:	8 80%	2 20%	0
OTHER THAN COMPATIBILITY WITH U.S. EQUIPMENT, DO YOU KNOW OF A NEED TO CONVERT AZIMUTHS TO DEFLECTIONS? COMMENTS:	0	10 100%	0
IF U.S. ARTILLERY EQUIPMENT WAS MODIFIED, DO YOU FEEL IT WOULD BE AN IMPROVEMENT TO USE AZIMUTHS AS OPPOSED TO DEFLECTIONS? COMMENTS:	9 100%	0	1
DO YOU KNOW OF ANY FIRING ERRORS THAT WERE CAUSED BY CONFUSION ABOUT DEFLECTIONS? COMMENTS:	9 100%	0	1
DO YOU FEEL THAT GUNNERS AND SECTION CHIEFS WOULD HAVE SIGNIFICANT PROBLEMS CONVERTING TO A SYSTEM OF AZIMUTHS IF GIVEN TRANSITION TRAINING? COMMENTS:	1 10%	9 90%	0
DO YOU KNOW OF WAY TO ALIGN GUNS OTHER THAN AZIMUTHS OR DEFLECTIONS? IF SO PLEASE DESCRIBE IT.	0	9 100%	1

*OTHER POSITIONS

*NR - NO RESPONSE

ASSISTANT DIVISION COMMANDER
ASSISTANT COMMANDANT, FA SCHOOL
CHIEF OF STAFF, FORT SILL, OKLAHOMA
DEPUTY ASSISTANT COMMANDANT, FA SCHOOL (2)
DIRECTOR TRAINING AND DOCTRINE, FA SCHOOL
DIRECTOR FIRE SUPPORT AND COMBINED ARMS OPERATIONS, FA SCHOOL
DIVISION FIRE SUPPORT COORDINATOR
CHIEF CANNON DIVISION, GUNNERY DEPT, FA SCHOOL (2)

QUESTIONNAIRE

Figure 4-1

of the survey are listed as the total number of persons responding to each question. At the top of the survey is a listing of the critical positions held by the participants. This listing is not the number of people that participated, but is a representation of the collective experience of the participants of the survey. Other positions not listed at the top of the form are included at the bottom. A total of 10 artillerymen participated in this survey. While this number seems to be small, the collective experience of the participants and the overwhelming agreement in the responses, validate the credibility of the information. These results will be included as data in the comparison of systems.

SAFETY

Safety is an essential aspect in the use of field artillery. The firing of field artillery weapons can be considered as a dangerous operation and any aspect that would aid in the safe operation of the weapon systems is important. The aspect of the comparison is that deflections are the incumbent system and azimuths are the challenger. With this in mind most of the information will attempt to prove that azimuths are either less or more safe than deflections.

Two questions on the survey dealt with safety. The first was, "Do you feel that the possibility for confusion exists over the conversion of azimuths to deflections?" The response from the survey population was that of ten persons responding eight felt that the possibility of confusion did exist, two thought that confusion was not an issue, of these two one added a comment that training was the element that prevented the confusion.[10] The other question that was associated with safety was "Do you know of any firing errors that were caused by confusion about deflections?" Of the ten persons questioned only nine responded, but all agreed that they did know of firing incidents caused by confusion over deflections.[11] Comments were made by several of the participants which reveal the nature of these errors.

One officer stated that in Vietnam he witnessed a unit that laid the howitzers on an azimuth of fire and then on the guns used a common deflection of 2400 mils. The fire direction center used a common deflection of 2800 mils. This error resulted in the unit firing a 400 mil error on each round fired.[12] If a system of azimuths was in use no conversion of the azimuth of fire would have been necessary and it is likely that this error or others of similar nature would not occur. Another error reported was that the azimuth of fire was very close to 3200 mils and the fire direction officer forgot to convert it to deflection 3200.[13] Confusion over the conversion was again a factor. If a system of azimuths was in use then there would have been no need for the forgotten conversion. Another error reported was in the use of safety cards. In the United States artillery, a safety card is prepared for each howitzer that provides the gun crew the data for the left and right limits of fire into the impact area. This information is displayed as deflections and once these limits are posted on the weapon system the chief of the howitzer section is assured that any deflection fired within that data will be safe for direction. When these cards are prepared the safety officer must convert the left and right safety limits from azimuths to deflections. One participant in the survey revealed an incident where the safety officer incorrectly converted these azimuths and posted incorrect data on the safety cards resulting in the unit firing out of the impact area.[14] If a system of azimuths were used the conversion of the azimuths to deflections would not have been required. One final incident that was reported was that the azimuth of lay was very close to 3200 and at the end of the procedure to lay the howitzer the displayed value on the sight was very close to 3200. With these values displayed the howitzer crew failed to depress the counter reset plunger on the sight to properly convert the azimuth of fire to deflection 3200, resulting in the howitzer firing an error.[15] The system of deflections can again be blamed as a contributor to this error because regardless of the azimuth of fire, the howitzer crew expects to fire deflections close to 3200 and this expectation was a key element in this incident.

Another aspect of safety is the section chief or safety officer has to convert the deflection to be fired to an azimuth before it can be independently checked and verified by a compass.[16] Since the fire commands are in deflections any evaluation of the direction of the cannon tube that is to be made with a compass involves a fairly lengthy math step. For instance, the azimuth of lay is 5450 with a common deflection of 3200. The howitzer is then commanded to fire deflection 2929. If a safety officer or howitzer section chief attempted to verify that the howitzer was oriented on the azimuth that related to deflection 2929 he must calculate the conversions displayed in figure 4-2.

COMMON DEFLECTION	3200
MINUS DEFLECTION ANNOUNCED	-2929
EQUALS MILS TO THE RIGHT, REMEMBERING THAT IN DEFLECTION VALUES TO THE RIGHT DECREASE	271
AZIMUTH OF LAY	5450
PLUS INCREASE IN MILS	+ 271
CORRECT AZIMUTH	5721

Figure 4-2

For the average person this conversion will require use of a pencil and paper and takes a considerable amount of time. If a system of azimuths were used the announced fire command would be "Azimuth 5721", the safety officer or section chief would then only have to check the direction of the cannon which should be azimuth 5721, with no conversion of figures.

Examples exist on training ranges where errors are fired with deflections being a primary cause in the accident. In a six month period in 1989 at the National Training Center there were two incidents where artillery units fired errors with the primary cause being a problem with the deflection system. In both instances the azimuth of fire was incorrectly entered into the computer.[17] With a system of deflections, the fire commands that are generated are based on deflections. Thus if a target on the azimuth of fire was to be engaged, the fire command would be "Deflection 3200." This is a value that is frequently announced to the howitzer and it is not unusual for the crew to hear this value or one close to it. The howitzer crew members have no choice but to assume that 3200 corresponds to the azimuth of fire. If a system of azimuths was used, it would be more apparent to the crew that the azimuth of fire and the announced values were different and the fire command would likely be questioned prior to firing the error. This logical relation of the direction of fire being the same as the command to fire would possibly have prevented these firing incidents.

Accidents from another range also imply that the system of deflections does contribute to errors. In just over a one year period two errors were fired, involving the system of deflections, at the Ft. Sill, Oklahoma ranges.[18] The first accident occurred when a howitzer was laid for direction with a 180 mil error in the azimuth of lay. Since the howitzer was using deflections it was given a common deflection of 3200. The fact that the howitzer was misoriented by 180 mils was partially disguised by the value of the orientation of the cannon being 3200. In a system of azimuths a simple check with a compass would have easily revealed that the howitzer was misoriented. The fact that deflections were used did not prevent the howitzer from being checked with a compass, however, based on figure 2-2 it is clearly a more complicated step when using deflections. The other incident occurred when the left and right safety markers were installed incorrectly. With the safety markers in error the howitzer crew thought the deflection fired was safe, when in fact the deflection fired caused the round to impact outside of the designated impact area. As in the other instance if a system of azimuths was used, verifying the placement of safety limits would be simplified by eliminating the math step required to verify deflections with a compass. In each of these instances a system of azimuths could have easily revealed the potential error before it was fired.

Even more dangerous than training errors are those that are fired in combat. The effects of these errors are more likely to cause damage to friendly troops or facilities. A report of a staff visit from the Artillery School to the combat zone in the Republic of Vietnam in June 1967 revealed that several firing incidents were related to the use of deflections. During this short time, 13 days, there were 6 firing incidents in which errors from 100 to 3200 mils were fired because of incorrect lay of the howitzers. All of these incidents involved weapons using a system of deflections. In each of these errors a simple check with a compass could have revealed the error prior to the accident and a system of azimuths would have aided in this safety check. In these accidents the costs of errors were high, 2 soldiers were killed and 14 were wounded.[19]

The preceding discussions on the safety aspect of deflections indicate that the system of azimuths might be safer than the system of deflections. Deflections, however, are not inherently unsafe. If all procedures are followed correctly the use of deflections is clearly a safe system. The evidence does indicate that the procedures that must be followed in using deflections are more complex and prone to error than a solution involving azimuths. Based on the ease verifying the direction of the cannon and the idea that azimuths are simpler to use, it can be concluded that a system of azimuths is safer than a system that uses deflections.

EFFICIENCY OF THE SYSTEM

Any system in use in a military application should be as efficient and simple as possible. It must be simple enough to be understood by the operators and must perform the intended task. A thorough understanding by the operator is necessary to ensure the ability to perform under combat conditions, often involving high levels of stress. The optimal fire control system is one that is accurate, efficient and understood by the operators of associated equipment. With this in mind azimuths and deflections will be compared based on their respective efficiency.

Both azimuths and deflections are based on the 6400 mil circle and thus both have the same accuracy. Even if fire control instruments were modified to have a smaller graduation neither system would be more accurate as long as the new graduations were applied to both systems. This modification would be only to the instruments and not to the actual system of azimuths or deflections.

The survey that was used had two questions that addressed the efficiency of the system. The first question was, "Other than compatibility with U.S. equipment, do you know of a need to convert azimuths to deflections?" The response to this question was unanimous. Of ten questioned, none knew of a reason to convert azimuths to deflections.[20] Since there is considerable math involved in this conversion it seems that the efficiency of deflections might not be as high as the system of azimuths where no conversion is needed.

The other question on the survey was, "If U.S. artillery equipment was modified, do you feel it would be an improvement to use azimuths as opposed to deflections?" The response to this question was that of ten questioned nine thought it would be an improvement to use azimuths. One officer did not respond to this question.[21] It would seem that even officers who have used deflections throughout their entire career would be happy to change to a system of azimuths with no sense of loss over the "tried and true" system of deflections. According to one Division Artillery commander, "I would change to azimuths today if the opportunity existed."[22]

With an entire compliment of trained artillerymen the logic that it would be difficult to convert these individuals to azimuths is presented. Research shows that other countries have made this transition and seem to think it is an improvement. The Venezuelan army has both azimuths and deflections present in the arsenal of their artillery force. The majority of the officers in that country prefer to work in the units that have the azimuth system, they feel that the system is easier and they understand it better.[23] The German army converted from deflections to azimuth in the mid 1960s. One officer who was serving in that period stated, "for many years the gunners had questioned the use of deflections and some actually had a difficult time understanding the system. Almost immediately after the introduction of the system of azimuths the soldiers commented that the system was much better and questioned why the army had not converted earlier."[24] Research would indicate that artillerymen who have used both systems prefer the azimuth system for its simplicity and ease of understanding.

Further interviews indicate that the system of azimuths would provide the members of the howitzer crew a better understanding of which direction their cannon is oriented. The Assistant Commandant of the Field Artillery School commented that using a system such as azimuths, "the section chief will have a better understanding of what direction his tube is pointed."[25] Another senior artilleryman simply stated that, "azimuths would be more easily understood on the gun line."[26] Both comments indicate that the individuals on the howitzers would have a better understanding of the direction of the tube if the value was expressed as an actual azimuth rather than the converted value of deflection, which is usually somewhere around 3200. A value close to 3200 is seen so often that the crew is sometimes virtually numb to the actual azimuth the howitzer tube is pointed.

The results of this research indicate that azimuths are a more efficient system than deflections. First, there is no need to convert to another value the direction you want the howitzer to be oriented on. Second, using examples of senior United States field artillerymen, it is felt that soldiers would understand the system of azimuths better. Third, other countries that have converted their systems to azimuths from deflections, or use both, find azimuths to be superior. Finally, even countries that do not use deflections have evaluated them and find no advantage to converting from azimuths to deflections. In fact comments from the Royal Artillery School indicate that "the sheer inconvenience of having to convert bearing [the British term for azimuth] to deflection are the chief failings of the deflection system. In the age of computers it seems wasteful to work out deflections when a bearing is easier to calculate and easier to apply."[27]

INTEGRATION INTO NEW SYSTEMS

The United States field artillery is constantly developing and researching new areas which the field artillery community might use. The two weapon systems mentioned in chapter II are Paladin and Advanced Field Artillery System (AFAS). These systems represent the weapon systems that will be used beginning in the mid 1990s until well into the 2000s. Each of these systems is based more closely on azimuths than deflections. Current weapons rely on the use of an aiming point visible from the gun and the operator of the sight on the weapon must align his sights on this during indirect fire. When this is done the tube of the howitzer is actually oriented based on an angle between the aiming point and howitzer tube. This is true for systems using both azimuths and deflections. Paladin and AFAS will not use an aiming point. Both systems will be oriented by the fire control equipment built in each weapon. The weapons will compute the data to the target and orient the howitzer onto the target based on its capability to determine the direction of north. A system of azimuths as used today will not duplicate this procedure, however, the transition to this system might be easier if the conversion was from azimuths as opposed to deflections.[28] Additionally, when these new systems are being introduced into service there will be a period of time when several different types of weapons will be in use. This period might even be longer in the reserves as opposed to the active force since the tendency is to supply the active force with the newest equipment first. During this time if the system of deflections is retained the artillerymen of the United States will be faced with the problem of some systems using deflections and some using azimuths to orient for direction. It appears that azimuths are more compatible with future systems than deflections.

TRAINING

Any system used in the military should be one that can be trained on efficiently. In the comparison of azimuths and deflections the amount of training required for each system should be examined. Since deflections are the standard in the United States field artillery it will be the base line for training requirements. Azimuths will be compared to this to determine whether training will be eased or burdened by the introduction of a new system.

The survey used in this research had one question specifically to training, "Do you feel that gunners and section chiefs would have significant problems converting to a system of azimuths if given transition training?" Of the ten responses to this question nine felt that no training problems would be incurred by the transition to azimuths.[29] This response tends to support the idea that the system of azimuths is easy to understand. Other responses from interviews support this tendency.

As stated earlier the German army did convert to azimuths from deflections in the mid 1960s. A participant in that conversion indicated that training was eased by the introduction of azimuths and that the system of azimuths was very simple for the soldiers to learn because it was based on common sense.[30] Others interviewed agreed that the system of azimuths is easier to train. Major Duncan Milne, the Canadian Liaison Officer to the United States Field Artillery School, was previously an exchange instructor to the U.S. Artillery School. Prior to his arrival at Ft. Sill he was trained as an instructor in the Royal Canadian

Artillery School, using a system of azimuths. This Canadian instructor training is a year long course that covers in detail all aspects of field artillery. When he arrived at Ft. Sill and participated in the local instructor training he encountered considerable problems with the conversion of azimuths to deflection. These difficulties were not a result of a person who did not understand the fundamentals of artillery, they were directly related to the complexity of the conversions required to use deflections.[31]

Another aspect of training is the amount of time it takes to initially train an individual. Orientation of the howitzer by azimuths must be trained on and understood by students prior to continuing with the explanation of and training on deflections.[32] If a system of azimuths were used then the subsequent training on deflections could be deleted. This deletion could reduce training time in the training institutions.[33] Training effectiveness could also be enhanced by the adoption of an azimuth system. The officers who supervise fire direction centers are trained on the deflection system and use it manually usually only at the Officer basic and advance courses at Ft. Sill. Otherwise the officers use automated systems to compute firing data. Prior to the introduction of computers all firing data was computed manually. The visual representation of deflections on the firing chart made it easier to understand the use of deflections. With the fire direction solutions being now almost exclusively automated the understanding of deflections is more difficult. The lack of use of the manual system enhances the chances of individuals not understanding deflections.[34] An azimuth system would be much more effective in a training sense because it is easier to understand.

The research indicates that a system of azimuths is more effective in training aspects than are deflections. Transition training would appear to be no significant problem and institutional training would be eased. Also those individuals who use a fire control system daily would appear to have a better understanding of azimuths as opposed to deflections. With these factors considered the conclusion drawn is that azimuths are superior to deflections as both relate to training.

INTEROPERABILITY

The ability to operate with our allies in future conflicts is likely to become more important as countries continue to group together for mutual defense. This cooperation can be more efficient and effective if similar weapon systems operate in much the same manner. The comparison of deflections and azimuths will be focused in this area on the ability of the United States artillery to operate with other countries' artillery systems.

As stated earlier many of our major allies use azimuths for orienting their artillery. These include but are not limited to Australia, Canada, France, Germany and the United Kingdom. The ability to use the howitzers of these countries and the associated fire control equipment could be of significant value in future conflicts. It is felt by one senior artilleryman that this issue is a significant reason for converting to a system of azimuths.[35] Based on the fact that other major allies use the system of azimuths and that deflections are not compatible with those systems, the ability to interoperate with our allies appears to be more feasible using a system of azimuths.

COSTS

With an artillery force as large as the one in the United States the cost of converting any system must be addressed. The actual value of this cost will not be presented in this research, however, issues relating to cost must be explored. The comparison will focus on costs associated with converting to a system of azimuths as well as possible savings to be gleaned from that conversion.

Converting to a system of azimuths would require modifications to all panoramic telescopes and fire direction computer software in the United States artillery inventory. The cost of this conversion would be enormous but it would not cover the entire bill. Publications associated with fire control would have to be modified as well as all training equipment that is deflection specific. For all the advantages gained in the other areas compared the cost would be great.

There are some costs that could be reduced by the introduction of azimuths. The funds needed for fire direction software in future versions could be reduced if a system of azimuths is used by eliminating the lines of program required to convert to deflections.[36] In the long run costs of institutional training could well be reduced by the ease of training using azimuths, as well as a potential reduction of the intangible costs associated with accidents and fratricide.[37] A system of azimuths would reduce training time in the institution and would produce some long term savings. The value of the cost of human suffering and loss cannot be calculated but certainly is a major factor to be considered.

Viewing the issue of cost from strictly a dollar perspective the advantage would certainly fall to the side of deflections. The savings associated with the use of azimuths while certainly feasible, do not appear to offset the cost of converting to a new system. The human factor as stated earlier cannot be factored as a dollar cost, however this must be considered in the total evaluation. For this comparison, however, the costs are to be viewed in a very broad sense and it seems that the system of deflections emerges as the most advantageous.

CHAPTER IV ENDNOTES

[1]Major Geoffry P. Jones, Australian Artillery Officer, Interview by author, 5 June 1988, Oromocto, New Brunswick, Canada, Author's notes.

[2]Major D.C.D. Milne, Canadian Liaison Officer to the United States Army Field Artillery School, Interview by author, 20 December 1991, Ft. Sill, Oklahoma, Author's notes.

[3]Lieutenant Colonel Jaques deVasselot, French Liaison Officer to the United States Army Field Artillery School, Interview by author, 26 February 1992, Ft. Sill, Oklahoma, Author's notes.

[4]Lieutenant Colonel Hans-Henning Sturm, German Liaison Officer to the United States Army Field Artillery School, Interview by author, 20 December 1991, Ft. Sill, Oklahoma, Author's notes.

[5]Lieutenant Colonel Peter J.H. Hurst, British Liaison Officer to the United States Army Field Artillery School, Interview by author, 20 December 1991, Ft. Sill, Oklahoma, Author's notes.

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[7]Major Paolo Ruggiero, Italian Field Artillery Officer, Interview by author, 27 February 1992, Ft. Leavenworth, Kansas, Author's notes.

[8]Lieutenant Commander Thomas Copeman, Officer in the United States Navy, Interview by author, 5 December 1992, Ft. Leavenworth, Kansas, Author's notes.

[9]Survey conducted by author, a summarization of the results are included in Figure 4-2, completed survey sheets are on file with author.

[10]Survey, results of.

[11]Survey, results of.

[12]Colonel William S. Pier, Director of Training and Doctrine, United States Army Field Artillery School, Interview by author, 19 December 1991, Ft. Sill, Oklahoma, Author's notes.

[13]Captain Joseph Napoli, Interview by author, 9 January 1992.

[14]Lieutenant Colonel Thomas Mackiewicz, Commander 1-33D Field Artillery and former Chief of Cannon Division, Gunnery Department, United States Army Field Artillery School, Interview by author, 20 February 1992, Ft. Sill, Oklahoma, Authors notes.

[15]Lieutenant Colonel Charles S. Soby, Chief of Cannon Division, Gunnery Department, United States Army Field Artillery School, Interview by author, 19 December 1992, Ft. Sill, Oklahoma, Author's notes.

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[17]National Training Center Take Home Packet, covering the reports from rotations 1-89 to 7-89, All information is on computer files in the Center For Army Lessons Learned, Ft. Leavenworth, Kansas.

[18]Daily Journal Extracts, Range Division, Range Control, Ft. Sill, Oklahoma, 1 January, 1989 to 31 December 1991.

[19]Colonel Tony F. Perpich, "Report of Staff Visit - RVN 8-21 June 1967", (Ft. Sill: United States Artillery and Missile School, 26 June 1967.

[20]Survey, results of.

[21]Survey, results of.

[22]Colonel John Ryneska, Commander 7th Infantry Division Artillery, Interview by author, 25 February 1992, Ft. Ord, California, Author's notes.

[23]Captain Joseph Napoli, Interview by author, 9 January, 1992.

[24]Lieutenant Colonel Hans-Henning Sturm, Interview by author, 20 December 1991.

[25]Brigadier General Tommy R. Franks, Assistant Commandant United States Army Field Artillery School, Interview by author, 20 December 1991, Ft. Sill, Oklahoma, Author's notes.

[26]Colonel Stanley E. Griffith, Director Target Acquisition Department, United States Army Field Artillery School, Interview by author, 20 December 1991, Ft. Sill, Oklahoma, Author's notes.

[27]Royal Artillery School, British and American Methods of Laying for Line (Larkhill, U.K.: The Royal Artillery School, 1963), 9.

[28]Brigadier General Tommy R. Franks, Interview by author, 20 December 1991.

[29]Survey, results of.

[30]Lieutenant Colonel Hans-Henning Sturm, Interview by author, 20 December 1991.

[31]Major D.C.D. Milne, Interview by author, 20 December 1991.

[32]Gunnery Department, "Lesson Plan GD02AC, Firing Charts" (Ft. Sill: U.S. Army Field Artillery School, 1989), 8.

[33]Lieutenant Colonel Charles S. Soby, Interview by author, 19 December 1991.

[34]Colonel Stanley E. Griffith, Interview by author, 20 December 1991.

[35]Lieutenant Colonel Thomas Mackiewicz, Interview by author, 20 February 1992.

[36]Lieutenant Colonel Charles S. Soby, Interview by author, 19 December 1991.

[37]Colonel David A. Rolston, Director Fire Support and Combined Operations Department, United States Army Field Artillery School, Interview by author, 19 December 1991, Ft. Sill, Oklahoma, Author's notes.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

With the presentation of research in chapter IV conclusions and recommendations can now be made. To quantify the conclusions a decision matrix will be used. Based on the determinations from this matrix the primary research question will be answered. After the conclusion is presented recommendations for implementation of that answer will be offered. Finally any research weaknesses will be addressed and suggestions given for areas requiring further research.

DECISION MATRIX

Azimuths and deflections were compared in chapter IV using the criteria of safety, efficiency, integration into new systems, training impacts, interoperability, and costs. The results of each of these areas were analyzed at the end of each discussion. The decision matrix records the results of that comparison and provides a quantitative display based on the research presented.

Not all of the criteria are of the same importance. Because of this each has been weighted based on its overall impact. The area of safety was determined to be the most important because of the direct association with human lives and property damage. Costs were then ranked the next most important criteria because of the finite amount of money to be spent on artillery development and improvements. The remaining areas were determined to have approximately the same relative value and each will be weighted equally. Figure 5-1 is a representation of these weighted values.

CRITERIA	WEIGHTED VALUE
SAFETY	3
EFFICIENCY OF THE SYSTEM	1
INTEGRATION IN TO NEW SYSTEMS	1
TRAINING ISSUES	1
INTEROPERABILITY	1
COSTS	2

WEIGHTED VALUE OF CRITERIA

FIGURE 5-1

The research presentation and information analysis in chapter IV indicated that azimuths are superior to deflections in most of the criteria evaluated. This information indicates that azimuths are a safer system. Azimuths were also rated best in efficiency, integration into new systems, training and interoperability. Deflections were determined to be the more cost effective system. An argument could be made that suggests the value of a human life is not comparable to any costs in equipment. That argument will not be challenged, however, for the purpose of this decision matrix the added advantage in the safety of azimuths is accounted for the increased weighting of safety. Accounting for human life in safety allows the criteria of costs to be evaluated on strictly a basis of dollars. The decision matrix is as shown in figure 5-2.

CRITERIA	WEIGHT	AZIMUTH		DEFLECTION	
		SCORE	*VALUE*	*SCORE*	*VALUE*
SAFETY	3	2	6	1	3
EFFICIENT	1	2	2	1	1
NEW SYS	1	2	2	1	1
TRAINING	1	2	2	1	1
INTEROP	1	2	2	1	1
COSTS	2	1	2	2	4
TOTAL			16		11

HIGHER SCORE IS BETTER

DECISION MATRIX

Figure 5-2

The subjective analysis incorperated in this matrix indicates that the better system for the United States field artillery is a system of azimuths. This system appears to be safer, easier to use and understand, more compatible with our new systems, and more interoperable with our major allies. The only major drawback to the use of azimuths is the high cost of system conversion.

RECOMMENDATIONS

The conclusions from this research indicate that a system of azimuths would be a better system for the United States artillery. A recommendation that the systems should be converted immediately would be very easy to suggest and is the optimal solution, however the realization that the funds are not immediately available dictate that a more reasonable approach be applied. The proper time to fully integrate azimuths into the United States field artillery is with the delivery of new systems as they are fielded beginning with the Paladin. All efforts should be made not to allow deflections to be introduced into this or any new system. One way to help ensure that this does not happen is to convert all systems to azimuths when the next new system is introduced. This solves two problems, first the artillery is finally able to divorce deflections and second it prevents the simultaneous use of both deflections and azimuths. Any earlier integration of azimuths would certainly be optimal, however, a realistic view would support conversion as new systems are introduced. The United States artillery community should be very aware that the possibility of having deflections introduced into any new system exists and should fight to the last moment to prevent this from occurring.

RESEARCH WEAKNESSES

One major concern in the research was the inability to identify why the Field Artillery School decided, in 1950, to give the term deflection a value. It is clear that this decision was made because of the change in the doctrinal literature, however, the reason for this change and the circumstances around it could not be located.

AREAS REQUIRING FURTHER RESEARCH

The scope of this research was limited to answering why we use deflections and are they the best system to use. Other items deserving research that precipitated from this thesis are (1) a study to determine the actual cost of converting to azimuths,(2) actual technical requirements for the modification of present sights to azimuths, and (3) actual requirements for the modification of fire direction software to use azimuths. Research in each of these areas would provide more details and data on how the United States field artillery should convert to a system of azimuths.

GLOSSARY

AIMING POINT. A sharply defined point or object on which the sight of a weapon is aligned when the weapon is laid for direction.[1]

AZIMUTH. A horizontal clockwise angle measured form north. A grid azimuth, measured from grid north, is the azimuth normally used in the field artillery.[2]

BARREL. A metal or plastic tube through which ammunition is fired and which controls the initial direction of a projectile.[3]

BREECH. The part of a firearm to the rear of the bore.[4]

CANNON. A complete assembly consisting of an artillery tube, a breech mechanism, a firing mechanism, and a sighting system mounted on a carriage.[5]

DEFLECTION. 1. The setting on the scale of a weapon sight to place the line of fire in the desired direction. 2. The horizontal clockwise angle between the axis of the tube and the line of sight.[6]

FIRE COMMANDS. Information given to howitzer sections from the fire direction center that allows them to start, conduct and cease firing.[7]

FIRE DIRECTION. The exercise of tactical command of one or more units in the selection of targets, the concentration or distribution of fire, and the allocation of ammunition for each mission. It also includes the methods and techniques used in fire direction centers to convert target information into appropriate fire commands.[8]

FIRE DIRECTION CENTER. The element of a command post consisting of gunnery and communications personnel and equipment by means of which the commander exercises fire direction and or fire control. The fire direction center receives target intelligence and requests for fire and translates them into appropriate fire commands.[9]

HOWITZER. A field artillery weapon characterized by a medium length barrel and a relatively high angle of fire, and a medium muzzle velocity.[10]

INDIRECT FIRE. 1. Fire delivered at a target not visible from the firing unit. 2. Fire delivered on a target that is not used as a point of aim for the weapon or the director.[11]

LINE OF SIGHT. Line of vision.[12]

MIL. A unit of measure for angles based on the angle subtended by 1/6400 of the circumference of a circle.[13]

MUZZLE. The forward, discharging end of the barrel of a firearm.[14]

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[1] TC 6-50 (1988), Glossary-6.

[2] Ibid., Glossary-6.

[3] TC 6-40 (1988), Glossary-5.

[4] The American Heritage Dictionary, 2D College Edition, s.v. "Breech."

[5] TC 6-40 (1988), Glossary-6.

[6] Ibid., Glossary-7.

[7] TC 6-50 (1988), 7-1.

[8] TC 6-40 (1988), Glossary-8.

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[10] TC 6-50 (1988), Glossary-9.

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